BIG SAGEBRUSH (*ARTEMISIA TRIDENTATA VASEYANA*) AND LONGLEAF SNOWBERRY (*SYMPHORICARPOS OREOPHILUS*) PLANT ASSOCIATIONS IN NORTHEASTERN NEVADA

Paul T. Tueller[1] and Richard E. Eckert, Jr.[2]

ABSTRACT—*Artemisia tridentata/Symphoricarpos oreophilus* and *Symphoricarpos oreophilus/Artemisia tridentata* plant associations were studied in northeastern Nevada. A 60-stand reconnaissance followed by a detailed study of 37 stands differentiated five important habitat types using an association table approach. Data reduction with DECORANA and TWINSPAN also described five plant associations that were differentiated by species occurrence and geographical distribution. All stands were found at elevations between 2,200 and 3,100 m in areas where snow accumulates and is late to melt. Stands are found on 15 families of soils that are relatively deep, often skeletal, dark colored, and productive. The dominant perennial grasses included *Agropyron spicatum*, *Agropyron trachycaulum*, and *Festuca idahoensis*.

Shrubby members of the genus *Artemisia* (sagebrush) comprise a significant portion of the vegetation in the Great Basin. Sagebrush gives the dominant aspect to vegetation over a wide range of altitude, climate, geological substrate, soils, and associated plant species. This environmental variability has resulted in a number of species, subspecies, and forms. In addition, a certain amount of hybridization has, no doubt, resulted in the existence of many ecotypes not yet defined (Beetle 1960, Winward and Tisdale 1969, and McArthur 1978).

Big sagebrush (*Artemisia tridentata*) is the most widely distributed and abundant species of the genus. Three subspecies have been identified, ssp. *vaseyana*, ssp. *tridentata*, and ssp. *wyomingensis*. Extensive stands of mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*) occur in central and northern Nevada in high-producing plant communities at high elevations. This study was limited to stands with either *Artemisia tridentata vaseyana* or snowberry (*Symphoricarpos oreophilus*) as the dominant or co-dominant shrub.

The objective of this study was to characterize the vegetation, topography, and soils of some *A. tridentata/S. oreophilus* habitat types in northeastern Nevada.

METHODS

This study was confined to mountainous areas in northeastern Nevada where *Artemisia tridentata vaseyana* and *Symphoricarpos oreophilus* are locally abundant. The overall climate is primarily arid (Hunt 1967), although semiarid to subhumid conditions exist in many of the mountain ranges.

Mountain brush vegetation dominated by shrubs of these two species was studied by first selecting 60 stands in 18 mountain ranges in Elko, Eureka, Humboldt, Lander, Lincoln, Nye, and White Pine counties for a detailed reconnaissance. The plotless reconnaissance procedure outlined by Poulton and Tisdale (1961) was used to collect general vegetation information. A stand was selected for sampling if it was homogeneous with respect to species composition and dominance and had uniform relief of the soil surface. Transitional areas were avoided. For each stand, species were listed under three categories (tree, shrub, or herb physiognomic layer) and given both cover class and dominance ratings.

Physiographic features of percent slope, slope aspect, position of the stand on the slope, elevation, land form, and microrelief of the soil surface were recorded. Soil profile features noted were horizons, solum depth, gross differences in the texture and structure, and quantity of gravel and stone. Percent cover for stone, gravel, bare soil surface, and cryptogams was estimated.

[1]Department of Range Ecology, University of Nevada, Reno, Nevada 89512.
[2]Agricultural Research Service, U.S. Department of Agriculture, Department of Range, Wildlife and Forestry, University of Nevada, Reno, 1000 Valley Road, Reno, Nevada 89512.

Based on results of this reconnaissance, 37 stands of vegetation in eight mountain ranges in Elko and White Pine counties were selected for more detailed study (Fig. 1). The stands selected were considered most nearly representative of the potential natural vegetation based on the absence of recent disturbance such as excessive grazing, wildfire, and accelerated erosion, and on a high proportion of grasses in the herb layer, particularly species of *Agropyron*, *Festuca*, and *Poa*. All stands were grazed by livestock during the summer months. Studies of relict and excellent condition sagebrush vegetation in other portions of the Great Basin have shown that grasses, particularly of the genera mentioned, comprised a dominant portion of the herb layer (Blackburn 1967, Blackburn et al. 1968b, c, 1969a, b, c, 1971, Passie and Hugie 1962, Tisdale et al. 1965, Zamora and Tueller 1973).

At each study site a homogeneous stand of vegetation was selected for sampling. Plant and ground cover data were collected on one 15- x 30-m macroplot located with the long axis oriented up and down slope. The right-hand boundary formed the baseline. Ten 15-m transects were located perpendicular to the baseline with five transects randomly placed in each half of the macroplot. Rooted frequency of all species was determined in 10 3- x 6-dm microplots placed at 1-m intervals along each transect line. Percent basal area of herbaceous species was estimated in 10 3- x 6-dm microplots on 4 of the 10 frequency transects. Two wire rings, one 5% and the other 2% of the microplot area, were used as an aid in estimation. Basal areas of 1 to 10% were estimated to the nearest 1%; those greater than 10% were estimated to the nearest 5%. Basal area for mat-forming species was considered as the total area encompassed by the periphery of the mat. Dead centers of bunchgrass were excluded from the cover estimate if they exceeded 1%.

Ground cover was estimated using the two outside corners of the microplot frame as points. Features recorded were basal area of plants, litter, cryptogam, bare soil surface, gravel (2-mm to 7-cm diameter), and stone (greater than 7-cm diameter). Percent cover was calculated from 200 points on each macroplot.

Shrub characteristics were evaluated on 15 1-m^2 microplots placed consecutively on the four transect lines to determine basal area of herbs. Shrub crown cover was estimated to the nearest 1% if less than 25% and the nearest 5% if greater than 25%. A wire ring equaling 5% of the microplot was used as an estimation. Openings in the shrub canopy greater than 2% were excluded from the cover estimate. Shrub density was obtained by counting individuals rooted in each microplot. The counts were summarized as numbers per 60 m^2. Shrub heights in each microplot were measured to the nearest centimeter.

A soil profile description was made at each macroplot location. Samples from the A1 and B2 horizons were analyzed for soluble salts, pH, and organic carbon.

Percent frequency and cover data were summarized in stand tables, and the resulting species groupings were used to make a subjective interpretation of the vegetation according to the association and habitat type ecological concepts. Final association interpretations were based on the dominant species in each plant layer. An association is defined as a plant community characterized by a definite floristic composition, physiognomy, and structure and growing under similar habitat conditions (Hanson and Churchill 1961). The associations are considered representative of potential native vegetation. A habitat type is defined as those geographic areas that support, or are capable of supporting, one association in the absence of disturbance (Daubenmire 1952). Habitat types are named by the characteristic climax plant association.

For objective analysis of the data we used the Cornell Ecology and Systematics computer programs DECORANA (Hill 1979) and TWINSPAN (Hill 1979). DECORANA (detrended correspondence analysis) creates ordinations of samples and all species. Through a process of repeated averaging, sample scores on the first axis of the ordination are defined as the average of the scores of the species that occur in a sample. Graphs showing placement of species and samples in relation to significant ordination axes are used with eigenvalues (to show variability) to explain the axes as ecological gradients. Each of the first three DECORANA ordination axes were analyzed by computing linear regression coefficients with the following stand parameters: elevations, radiation index (Frank and Lee 1966), shrub cover, grass cover, forb

TABLE 1. *Artemisia tridentata vaseyana/Symphoricarpos oreophilus* associations characterized in northeastern Nevada.

Associations	Number of stands sampled	Elevational range of stands (m)
Artemisia tridentata-Symphoricarpos oreophilus/Agropyron spicatum	14	2378-3010
Artemisia tridentata-Symphoricarpos oreophilus/Agropyron trachycaulum	6	2592-2713
Artemisia tridentata-Symphoricarpos oreophilus/Festuca idahoensis	5	2531-2592
Symphoricarpos oreophilus/Artemisia tridentata/Argropyron spicatum	10	2287-3003
Symphoricarpos oreophilus/Artemisia tridentata/Festuca idahoensis	2	2470

cover, total cover, number of species, latitude, and longitude. TWINSPAN (two-way indicator species analysis) successively splits the ordination of all the samples into halves and identifies indicator species for each division. The divisions are arranged in the printout in order showing the closeness of similarity between groups based on all species. The result is a classification of similar stands with the tightness of the groupings indexed by the eigenvalue of the division. The resulting classifications for both association tables and multivariate approaches were compared. We wanted to know if the multivariate approach, emphasizing all species equally, would describe plant associations readily identifiable in the field and potentially useful to resource managers.

RESULTS

Reconnaissance

Reconnaissance data allowed us to identify 15 mountain brush communities based on dominant species in the shrub and herb layer:

(1) *Artemisia tridentata–Symphoricarpos oreophilus/Agropyron spicatum*
(2) *Artemisia tridentata–Symphoricarpos oreophilus/Chrysothamnus viscidiflorus*
(3) *Artemisia tridentata–Symphoricarpos oreophilus/Chrysothamnus viscidiflorus/Agropyron spicatum*
(4) *Artemisia tridentata–Symphoricarpos oreophilus/Festuca idahoensis*
(5) *Artemisia tridentata–Symphoricarpos oreophilus/Poa sandbergii*
(6) *Artemisia tridentata–Symphoricarpos oreophilus/Stipa comata*
(7) *Artemisia tridentata–Purshia tridentata/Agropyron spicatum*
(8) *Artemisia tridentata–Purshia tridentata/Festuca idahoensis*
(9) *Artemisia tridentata–Cercocarpos ledifolius/Agropyron spicatum*
(10) *Artemisia tridentata–Chrysothamnus viscidiflorus/Agropyron spicatum*
(11) *Symphoricarpos oreophilus–Artemisia tridentata/Agropyron spicatum*
(12) *Symphoricarpos oreophilus–Artemisia tridentata/Agropyron trachycaulum*
(13) *Symphoricarpos oreophilus–Artemisia tridentata/Festuca idahoensis*
(14) *Symphoricarpos oreophilus–Artemisia tridentata/Poa sandbergii*
(15) *Symphoricarpos oreophilus–Artemisia tridentata–Amelanchier pallida/Agropyron spicatum*

Provisional association names were given to groups of stands with the same dominant species, the same combination of dominant species, or similar estimated cover percentages of certain species. Similarities among site factors such as elevation, aspect, percent slope, position on slope, and some soil characteristics (texture, structure, and percent sand and clay) were used as additional classification criteria.

Some of these 15 communities were judged to be seral stages of major associations. Others were grouped into one of the five final designations and considered to be incidental variants. The remaining communities (8, 9, and 15) were excluded from the study because they did not fit the criteria selected for the detailed analysis.

Intensive Study

Knowledge gained during the reconnaissance suggested that intensive work be confined to five (5) *Artemisia tridentata vaseyana–Symphoricarpos oreophilus* associ-

TABLE 2. Average density (No.), height (Ht.), and crown cover (Cv) for shrubs of the mountain brush plant associations.

Species	Association														
	Artr-Syor/Agsp			*Artr-Syor/Agtr*			*Artr-Syor/Feid*			*Syor-Artr/Agsp*			*Syor-Artr/Feid*		
	No.[a]	Ht. cm[b]	Cv %[c]	No.	Ht. cm	Cv %	No.	Ht. cm	Cv %	No.	Ht. cm	Cv %	No.[a]	Ht. cm	Cv %
Amelanchier pallida	2	171	T[d]	—	—	—	—	—	—	e	67	T[d]	—	—	—
Artemisia tridentata (Artr)	59	67	23	73	75	26	61	69	30	49	60	17	83	72	15
Berberis repens	—	—	—	e	5	T	—	—	—	—	—	—	1	3	T
Chrysothamnus viscidiflorus	16	19	2	18	27	2	24	30	2	28	29	5	35	34	4
Gutierrezia sarothrae	e	12	T	—	—	—	—	—	—	—	—	—	—	—	—
Pontentilla glandulosa	—	—	—	e	34	T	—	—	—	—	—	—	—	—	—
Prunus virginiana	e	25	T	—	—	—	—	—	—	—	—	—	—	—	—
Purshia tridentata	2	63	T	e	58	T	—	—	—	—	—	—	—	—	—
Ribes velutinum	—	—	—	—	—	—	—	—	—	5	33	T	—	—	—
Rosa woodsii	e	31	T	—	—	—	—	—	—	e	31	T	—	—	—
Symphoricarpos oreophilus (Syor)	322	43	17	118	36	14	311	39	18	394	33	21	259	43	22
Tetradymia canescens	e	28	T	—	—	—	—	—	—	—	37	T	—	—	—

a - Number per 60 m^2
b - Average height (cm) values calculated for stands in which individuals occurred
c - Average canopy cover percentage for a square meter
d - Cover values less than 1% indicated as *T*
e - Average density value less than 1
Agtr = *Agropyron trachycaulum*; Agsp = *Agropyron spicatum*; Feid = *Festuca idahoensis*

TABLE 3. Constancy (Cn), frequency (Fr), and herb basal area (Cv) for species in the *Artemisia tridentata vaseyana/Symphoricarpos oreophilus* associations.

Species[a]	*Artemisia tridentata vaseyana-Symphoricarpos oreophilus-Agropyron trachycaulum*			*Artemisia tridentata vaseyana-Symphoricarpos oreophilus-Festuca idahoensis*			*Artemisia tridentata vaseyana-Symphoricarpos oreophilus-Agropyron spicatum*		
	Cn	Fr	Cv	Cn	Fr	Cv	Cn	Fr	Cv
SHRUBS									
Amelanchier pallida	—	—	—	—	—	—	60	1	—
Artemisia tridentata	100	35	—	100	27	—	100	14	—
Chrysothamnus viscidiflorus	100	7	—	100	11	—	100	0	—
Purshia tridentata	—	—	—	40	1	—	—	—	—
Symphoricarpos oreophilus	100	10	—	100	5	—	100	8	—
HERBS (Grasses)									
Agropyron spicatum	33	1	T[b]	100	6	0.2	100	6	1.5
Agropyron trachycaulum	100	4	2.1	40	3	0.5	—	—	—
Bromus carinatus	17	1	0.1	—	—	—	—	—	—
Bromus marginatus	17	1	T	—	—	—	—	—	—
Bromus tectorum	67	2	T	80	5	0.3	87	4	0.1
Festuca idahoensis	83	6	1.0	100	5	2.7	47	3	0.3
Poa secunda	100	7	1.0	60	2	1.0	93	2	T[b]
Sitanion hystrix	17	2	T	—	—	—	—	—	—
(Forbs)									
Achillea millifolium	—	—	—	40	5	T	80	2	T
Agastache urticifolia	—	—	—	—	—	—	13	2	T
Agoseris glauca	33	6	0.1	60	3	T	33	2	T
Astragalus beckwithii	33	1	T	—	—	—	—	—	—
Balsamorhiza sagittata	50	4	T	40	2	T	80	5	T
Collinsia parviflora	100	9	0.4	100	9	0.3	73	3	0.3
Comandra pallida	—	—	—	40	2	T	—	—	—
Crepis acuminata	100	10	T	100	10	0.4	100	6	0.2
Eriogonum ovalifolium	50	2	0.3	—	—	—	27	1	T
Lupinus caudatus	100	12	0.2	100	15	1.2	100	7	0.4
Mertensia oblongifolia	83	9	0.2	100	8	0.4	100	8	0.3
Myosotis scorpioides	—	—	—	—	—	—	20	2	T
Penstemon hymilis	50	1	T	80	2	T	87	3	T
Phlox longifolia	33	1	T	60	9	0.1	27	2	T
Viola beckwithii	100	7	T	—	—	—	—	—	—

a - Only species with frequencies of 1% or greater in the 3- x 6-dm microplot are shown.
b - Average basal area less than 0.1% is indicated by T.

TABLE 4. Constancy (Cn), frequency (Fr), and herb basal area (Cv) for species in the *Symphoricarpos oreophilus/Artemisia tridentata vaseyana* associations.

Species[a]	*Symphoricarpos oreophilus-Artemisia tridentata vaseyana-Agropyron spicatum*			*Symphoricarpos oreophilus-Artemisia tridentata vaseyana-Festuca idahoensis*		
SHRUBS	Cn	Fr	Cv	Cn	Fr	Cv
Amelanchier pallida	22	1	—	—	—	—
Artemisia tridentata	100	17	—	100	16	—
Chrysothamnus viscidiflorus	100	21	—	100	12	—
Ribes velutinum	56	5	—	—	—	—
Symphoricarpos oreophilus	100	8	—	100	9	—
HERBS (Grasses)						
Agropyron spicatum	100	9	2.1	—	—	—
Agropyron trachycaulum	—	—	—	40	2	0.1
Bromus tectorum	89	4	0.1	100	8	0.2
Festuca idahoensis	78	6	T[b]	100	54	1.31
Melica bulbosa	11	1	T	—	—	—
Poa secunda	100	15	0.7	100	2	2.0
Stipa thurberiana	11	4	T	—	—	—
(Forbs)						
Achillea millifolium	33	2	T	—	—	—
Agoseris glauca	78	19	0.3	—	—	—
Aster scopulorum	67	4	T	—	—	—
Balsamorhiza sagittata	89	4	0.1	50	4	T
Collinsia parviflora	100	11	1.1	100	4	0.3
Crepis acuminata	89	8	0.2	100	6	0.1
Delphinium andersoni	78	4	T	—	—	—
Eriogonum ovalifolium	11	3	T	—	—	—
Geranium viscossium	11	2	T	—	—	—
Hydrophyllum capitatum	67	3	T	50	10	0.2
Lomatium cous	44	1	T	—	—	—
Lupinus caudatus	100	7	0.3	100	9	0.8
Mertensia oblongifolia	89	9	0.7	100	10	0.3
Penstemon humilis	89	4	0.1	—	—	—
Phlox longifolia	78	4	T	—	—	—
Senecio canus	67	7	T	—	—	—
Viola beckwithii	22	2	T	100	4	0.1

a - Only species with frequencies of 1% or greater in the 3- x 6-dm microplot are shown.
b - Average basal area less than 0.1% is indicated by *T*.

ations only (Table 1). These associations have the widest distributions and greatest abundance among the mountain brush plant associations of northern and central Nevada. These associations are described below, followed by the description and interpretation of the multivariate analysis. Data describing each plant association come from an association table which is on file at the University of Nevada, Reno. Vegetation characteristics for the five associations are presented in Tables 2, 3, and 4.

***Artemisia tridentata vaseyana–Symphoricarpos oreophilus/Agropyron spicatum* Association.**—This association is widely distributed throughout northern Nevada. Stands are located in mountainous terrain (2,378–3,010 m) in concave snowpockets on 16 to 31% slopes with predominantly northern aspects. Species composition of this association is very similar among stands in Elko County. Stands from White Pine County show greater variability.

The diagnostic characteristic of this association is the dominance of *Artemisia tridentata* in the shrub layer and of *Agropyron spicatum* in the herb layer. The average density of *Artemisia tridentata* (59 plants/60 m^2) is the lowest of the three associations with *A. tridentata* the dominant shrub (Table 3). *Artemisia tridentata* constitutes 55% of the total shrub crown cover, whereas *Symphoricarpos oreophilus* makes up 40% of the cover. *Symphoricarpos oreophilus* always has a high density but a low cover (Table 2). The average

TABLE 5. Soil surface characteristics for the associations dominated by *Artemisia tridentata vaseyana* or *Symphoricarpos oreophilus*.

Association	Soil surface characteristics					
	Plant cover %	Litter cover %	Bare soil surface %	Gravel cover %	Stone cover %	Cryptogam cover %
Artemisia tridentata-Symphoricarpos oreophilus/ Agropyron spicatum						
Average	39	32	19	7	2	Trace
Range	21–49	20–47	5–30	1–13	0–5	0–2
Artemisia tridentata-Symphoricarpos oreophilus/ Agropyron trachycaulum						
Average	36	27	24	9	2	2
Range	29–41	15–40	16–34	0–18	0–7	0–6
Artemisia tridentata-Symphoricarpos oreophilus/ Festuca idahoensis						
Average	42	39	15	2	Trace	2
Range	34–48	21–46	4–34	0–9	0–2	0–2
Symphoricarpos oreophilus Artemisia tridentata/ Agropyron spicatum						
Average	42	31	15	7	Trace	Trace
Range	37–47	17–48	8–26	1–12	0–2	0–2
Symphoricarpos oreophilus Artemisia tridentata/ Festuca idahoensis						
Average	41	36	14	6	2	1
Range	37–45	21–50	3–26	1–12	0–4	0–2

height of *A. tridentata* varies from 55 to 75 cm. *Chrysothamnus viscidiflorus* is 100% constant but contributes little to total plant cover. Eight other shrub species are found in these stands.

Four grass species and 12 forb species are found in this plant association (Table 3). Basal area and frequency of *Agropyron spicatum* is much greater than for any other herb in all stands. This species constitutes 79% of the total grass basal area and 48% of the total basal area of the herb vegetation. *Festuca idahoensis* and *Lupinus caudatus* are subdominant species in the herb layer. Total basal area of forbs is the lowest among all associations and is the most variable vegetation characteristic among stands in this association. Forbs with high constancy are *Archillea millifolium*, *Balsamorhiza sagittata*, *Collinsia parviflora*, *Crepis acuminata*, *Delphinium andersonii*, *Lupinus caudatus*, *Mertensia oblongifolia*, and *Penstemon humilis*. *Viola beckwithii* is highly constant among the stands in White Pine County but absent in the Elko County stands. *Lithospermum ruderale* is a characteristic species of stands in the northern Ruby Mountains and Jarbidge areas but is absent in White Pine County.

Basal plant cover and litter cover are comparatively high, 39% and 32% respectively (Table 5). The bulk of the litter occurs underneath and around the periphery of shrub crowns and consists primarily of leaf material from the shrubs, particularly *A. tridentata* and *S. oreophilus*. Few plants occur underneath the crown of *A. tridentata*, but nearly always plants of several species grow underneath the canopy of *S. oreophilus*.

TABLE 6. List of soil families supporting *Artemisia tridentata vaseyana* and *Symphoricarpos oreophilus* plant associations.

Soil family	Artr-Sylo/ Agsp %	Artr-Sylo/ Agtr %	Artr-Sylo/ Feid %	Sylo-Artr/ Agsp %	Sylo-Artr/ Feid %
Argic Cryoboroll, clayey over sandy or sandy-skeletal, montmorillonitic	27	—	—	—	—
Argic Cryoboroll, fine-loamy, mixed	—	—	20	—	—
Argic Pachic Cryoboroll, clayey over sand or sandy-skeletal, montmorillonitic	—	16	—	—	—
Argic Pachic Cryoboroll, fine-loamy, mixed	13	17	20	22	—
Argic Pachic Cryoboroll, fine-loamy over sandy or sandy-skeletal, mixed	—	17	—	—	—
Argic Pachic Cryoboroll, fine, montmorillonitic	—	—	—	45	—
Mollic Cryoboralf, clayey over sandy or sandy-skeletal, montmorillonitic	—	—	—	—	—
Mollic Cryoboralf, fine-loamy, mixed	20	33	20	11	50
Mollic Cryoboralf, fine, montmorillonitic	13	—	20	—	—
Mollic Cryoboralf, fine-loamy over sandy or sandy-skeletal, mixed	13	—	—	—	—
Ochreptic Cryoboralf, loamy, mixed	7	—	—	—	—
Typic Cryoboralf, fine-loamy, mixed	—	17	—	—	—
Typic Cryoboralf, fine-loamy over sandy or sandy or sandy-skeletal, mixed	—	—	—	—	50

Agsp = *Agropyron spicatum*
Agtr = *Agropyron trachycaulum*
Artr = *Artemisia tridentata*
Feid = *Festuca idahoensis*
Sylo = *Symphoricarpos oreophilus*

Soils are largely cryoborolls or cryoboralfs; 27% are Agric Cryoborolls, while 53% are one of four families of Mollic Cryoboralfs (Table 6). Many of the soils have dark brown to dark reddish brown, sandy loam and clay loam, angular and subangular blocky argillic horizons. Average solum gravel content varies from 10 to 30%. Thickness of the solum ranges from 42 to 98 cm. Most of the soils have fine-loamy textures (Table 7). Surface soils generally have low gravel and stone cover and small amount of bare soil (19%) due to high plant and litter cover.

***Artemisia tridentata vaseyana–Symphoricarpos oreophilus/Agropyron trachycaulum* Association.**—Stands representing this association are located in the Schell Creek Range, Ward Mountain, and Mt. Moriah areas of White Pine County with one stand in Elko County. All are located in mountainous terrain on concave to gently convex slopes with northeastern and northwestern aspects. Slopes range from 12 to 38%, and elevations range from 2,592 to 2,713 m.

The dominance of *Artemisia tridentata* in the shrub layer and *Agropyron trachycaulum* in the herb layer characterize this association (Table 3). The average density of *A. tridentata* (73 plants/60 m^2) is next to the highest of all associations studied (Table 3). Average cover of *A. tridentata* (26%) is 62% of the total shrub crown cover. *Symphoricarpos oreophilus* cover (14%) constitutes 33% of cover. The average density of *S. oreophilus* (181 plants/60 m^2) is the lowest among the associations studied (Table 3). Shrubs of secondary importance are *Chrysothamnus viscidiflorus* and *Purshia tridentata*.

Fourteen grass species constitute 78% of a total grass basal area of 4.2%. Basal area of *Agropyron trachycaulum* (2.1%) constitutes 50% of the total grass basal area and 39% of the basal area of all vegetation (5.4%). *Festuca idahoensis* and *Poa sandbergii* are subdominant species. The forb component (22 species) is very similar in composition to that of the *Artemisia tridentata vaseyana–Symphoricarpos longiflorus/Festuca idahoensis* association. Characteristic species with 50% constancy are *Collinsia parviflora*, *Crepis acuminata*, *Lupinus caudatus*, *Balsamorhiza sagittata*, *Eriogonum ovalifolium*, *Mertensia oblongifolia*, and *Penstemon humillis* (Table 3).

Combined plant and litter cover accounts for 63% of the soil surface cover. The amount

TABLE 7. Summary of textural classes[a] and diagnostic horizons of soils supporting stands of *Artemisia tridentata* and *Symphoricarpos oreophilus*.

Associations and number of stands sampled	Soil family texture class in control section						Diagnostic horizons			
							Epipedons		Subsurface horizons	
	Coarse-loamy	Fine-loamy	Fine	Very fine	Loamy-skeletal	Clayey-skeletal	Mollic	Ochric	Argillic	Cambic
	%[b]						%		%	
Artr-Sylo/ Agsp (14)	—	47	13	—	7	33	40	60	93	7
Artr-Sylo/ Agtr (6)	—	67	—	—	16	17	67	33	83	17
Artr-Sylo/ Feid (5)	—	60	20	—	—	20	40	60	100	—
Sylo-Artr/ Agsp (10)	22	33	45	—	—	—	78	22	78	22
Sylo-Artr/ Feid (2)	—	100	—	—	—	—	—	100	50	50

a - Soil family textural classification in soil taxonomy (Soil Survey Staff 1975)
b - Percent of stands

Artr – *Artemisia tridentata*
Sylo – *Symphoricarpos longiflorus*
Agsp – *Agropyron spicatum*
Agtr – *Agropyron trachycaulum*
Feid – *Festuca idahoensis*

of bare soil (24%) is the highest of all associations, and gravel cover and stone cover are 9% and 2%, respectively (Table 5).

Soils are both cryoboralfs and cryoborolls (Table 6). The cryoborolls are all Argic Pachic Cryoborolls with fine-loamy to sandy-skeletal textures (Table 7). The epidedons are predominantly mollic, and most soils (83%) have argillic subsurface horizons. Average gravel content varies from 5 to 25%. Only one profile was found on bedrock (74 cm deep).

***Artemisia tridentata vaseyana–Symphoricarpos oreophilus/Festuca idahoensis* Association.**—Two of the stands representing this association are located on Spruce Mountain, two on Mt. Moriah, and one in Harrison Pass. Each stand occurs in mountainous terrain on 19 to 29% slopes with north, east, and west aspects and elevations of 2,531 to 2,592 m.

The vegetation is characterized by the dominance of *A. tridentata* in the shrub layer (Table 2) and *Festuca idahoensis* in the herb layer (Table 3). *Artemisia tridentata* cover of 30% constitutes 60% of the total shrub crown cover and has a density of 61 plants/60 m^2. *Symphoricarpos oreophilus* cover of 18% constitutes 36% of the total shrub crown cover and has a very high density (311 plants/60 m^2) (Table 3). *Chrysothamnus viscidiflorus* is one of four highly constant shrubs but contributes little to total crown cover.

The total grass basal area (4.7%) is composed almost entirely of *Festuca idahoensis* (2.7%) and *Poa sandbergii* (1.0%); *Agropyron trachycaulum* is a minor species. Only six grass species were found. *Festuca idahoensis* comprises 38% of the total herbaceous basal area and 58% of the total grass basal area. The total herbaceous basal area (7.1%) and the total grass basal area (4.7%) are the highest of the associations studied. The total forb basal area (2.4%) is the highest among *A. tridentata*–dominated stands. The forb component consists of 20 species. Species with 80% constancy or greater are *Collinsia parviflora*, *Crepis acuminata*, *Lupinus caudatus*, *Mertensia oblongifolia*, *Penstemon humilis*, and *Viola beckwithii*. The first four species are the most abundant.

Average plant basal area cover (42%) and litter cover (39%) are the highest of all associations studied (Table 5). Gravel, stone, and cryptogam cover is very low. The bare soil surface (15%) is intermediate for all associations studied but is the lowest with respect to other *A. tridentata*–dominated plant communities.

At least 60% of the soils are Mollic Cryoboralfs with a few Argic Pachic Cryoborolls (Tables 6, 7). All subsurface horizons are argillic, and ochric epipedons are common. The most common soil family textural class is fine-loamy (Table 7).

***Symphoricarpos oreophilus–Artemisia tridentata vaseyana/Agropyron spicatum* Association.**—This association occurs in the southern Schell Creek Range with three exceptions. Two stands are in the Jack Creek area of Elko County and one stand is on Spruce Mountain. Stands are found on 10 to 30% slopes with northerly aspects at elevations between 2,287 and 3,003 m.

Robust *Symphoricarpos oreophilus* shrubs and an herb layer dominated by *Agropyron spicatum* characterize the vegetation (Tables 2, 4). In addition, this association has less *A. tridentata* (17%) than did the first three associations described. *Symphoricarpos oreophilus* cover (21%) comprises 49% of the total shrub cover and has the highest shrub density (394 plants/60 m^2) of all associations studied. *Artemisia tridentata* constitutes 38% of the shrub crown cover but has a very low density (49 plants/60 m^2). Besides *S. oreophilus* and *A. tridentata*, *Chrysothamnus viscidiflorus* is the only other important shrub, although *Ribes velutinum* has a constancy of 5% (Table 4).

Agropyron spicatum and *Poa secunda* have 100% constancy in this association. Fourteen grass species were found. *Agropyron spicatum* cover (2.1%) comprises 41% of the total herbaceous basal area (5.9%) and 68% of the total grass basal area (3.1%). *Lupinus caudatus* and *Collinsia parviflora* have constancies of 100% and contribute 50% of the total forb basal cover (28%) for 32 forb species. *Mertensia oblongifolia* and *Agoseris glauca* have constancies of 89% and 78%, respectively, and contribute 40% of the average total forb basal area (Table 4). *Festuca idahoensis* and *Senecio canus* have low constancies but comprise a significant portion of the total forb basal area in some stands. Other forbs characteristic of this association are *Penstemon humilis*, *Crepis acuminata*, and *Balsamorhiza sagittata*.

Plant and litter cover combined (73%) is the lowest of the *S. oreophilus* plant associations and is related to the high bare soil surface percentage of 19% (Table 5). Gravel cover (7%) was next to the highest among all the associations, but stone and cryptogam cover was the lowest of all associations.

Nearly half of the soils are fine, montmorillonitic Argic Pachic Cryoborolls (Table 6). Another 22% are a fine-loamy, mixed family of the same soil subgroup.

***Symphoricarpos oreophilus–Artemisia tridentata vaseyana/Festuca idahoensis* Association.**—Two stands represent this association, one on Mt. Moriah and the other on Ward Mountain in White Pine County. These stands occur on 26 and 28% slopes, respectively, and with northeast and northwest aspects at about 2,470 m.

The vegetation is characterized by the dominance of *Symphoricarpos oreophilus* in the shrub layer and *Poa sandbergii* and *Festuca idahoensis* in the herb layer (Tables 2, 4).

The physiognomy of this association is quite distinct from other plant associations because of the lack of a noticeable sagebrush aspect. These sites are snowpockets and are obviously dominated by *S. oreophilus*, a dark green shrub generally lacking the dull gray appearance of *A. tridentata*. *Symphoricarpos oreophilus* has a high density and a cover (22%) that comprises 53% of the total shrub crown cover (Table 2).

The average total basal area of herbaceous vegetation (5.1%) and the average total grass basal area (3.3%) are comparatively low when compared with the other associations in this study. *Poa sandbergii* has 2% cover and *Festuca idahoensis* has 1% cover (Table 4). Neither grass is clearly dominant. The association was named after *Festuca idahoensis* because it is considered to be the dominant perennial grass on these sites. *Poa sandbergii* composes 61% of the total grass basal area and 40% of the total basal area of herbaceous vegetation. All other grass species have low basal area and frequency, except *Festuca idahoensis*. Forbs are sparse; only 23 species were found, and frequency percentages are low. The floristic structure of forbs resembles the *Artemisia tridentata vaseyana–Symphoricarpos oreophilus/Festuca idahoensis* association, which had both low forb constancy and frequency. Highly constant forbs are *Collinsia parviflora*, *Crepis acuminata*, *Mertensia oblongifolia*, *Lupinus caudatus*, and *Viola beckwithii*.

Bare soil surface is the lowest of the associations studied and results from a high plant and

TABLE 8. Number of stands sampled falling into either TWINSPAN groups or plant associations based on dominant species.

Plant associations	TWINSPAN group					
	C	E	B	D	A	Totals
Artr/Syor/Agsp	4	7	3	—	—	14
Syor/Artr/Agsp	—	2	1	—	7	10
Artr/Syor/Agsp	—	—	3	3	—	6
Syor/Artr/Feid	—	—	1	1	—	2
Artr/Syor/Feid	—	—	2	1	2	5
Totals	4	9	10	5	9	37

Artr = *Artemisia tridentata* Syor = *Symphoricarpos oreophilus*
Agtr = *Agropyron trichophorum* Agsp = *Agropyron spicatum*
Feid = *Festuca idahoensis*

litter cover. Gravel, stone, and cryptogam cover is very low. One soil is a fine-loamy to sandy-skeletal Typic Chryochrept and the other a mollic Cryoboralf (Table 7). Both soils are neutral in reaction with roots well distributed throughout the profile.

Multivariate Analysis

The TWINSPAN classification clearly did not separate the plant associations in the same way as did the associations table groupings which were based on the dominant shrub and the dominant perennial grass (Fig. 4, Table 8). The TWINSPAN dendrogram organized the study site into five groupings based on the similarity of occurrences of specific indicator species. These floristically based groups had specific geographic locations (Fig. 1). Their distribution, with only a few exceptions, is characterized by a north-south orientation and by association with specific mountain ranges. These results are an expression of the north-south environmental control of the indicator species delineated by the TWINSPAN analysis. Environmental controls are such that many groupings are found only on certain mountain ranges or only in the north or south part of the study area. The TWINSPAN groups were associated with one, two, or three plant associations with the exception of Group B which has representatives from each association (Table 8).

Group A is separated with the following indicator species: *Astragalus kentrophyta implexus*, *Hydrophyllum capitatum*, *Senecio canus*, *Astragalus* sp., and *Ribes velutinum*. *Elymus cinereus* and *Phlox longifolia* are also indicators but less definitive than those listed above. *Lithospermum ruderale* is conspicuous by its absence. These stands are found primarily at the southern end of the site distribution and have *Agropyron spicatum* as the dominant perennial grass. Aspects are northwest and are found at relatively high elevations, mostly above 2,800 m. These stands tend to be much drier than expected for their elevation with relatively low vegetation cover (43%).

Group B indicator species include *Agropyron trachycaulum* and *Sitanion hystrix*, although the latter species is not a strong preferential. *Phlox longifolia* tends to be absent as does *Delphinium andersonii*. These sites are found at intermediate elevations (mostly below 2,600 m) on northeast aspects and are probably drier than Group A. However, these stands had the highest total vegetation cover of all stands studied (65%).

Group C has the following species as indicators: *Eriogonum ovalifolium*, *Stipa comata*, *Collinsia parviflora*, and *Allium acuminatum*. *Agoseris glauca* and *Phlox longifolia* are noticeably absent. These stands are found in the south Ruby Mountains at elevations near 2,400 m. However, they are relatively moist sites, wetter than would be expected for the elevation.

Group D has *Astragalus calycosus*, *Berberis repens*, and *Myosotis scorpiodes* as indicator species. *Balsamorhiza sagittata* and *Agoseris glauca* tend to be absent from these stands. They tend to be average in terms of elevation (2,600 m) and moisture.

Group E indicators are *Calychortus elegans*, *Rosa woodsii*, and *Tetradymia canescens*. *Festuca idahoensis* is generally missing in these stands. *Elymus cinereus* is also important in this group of stands. They occur at relatively low elevations (< 2,500 m) in the northern part of the distribution (Fig. 1).

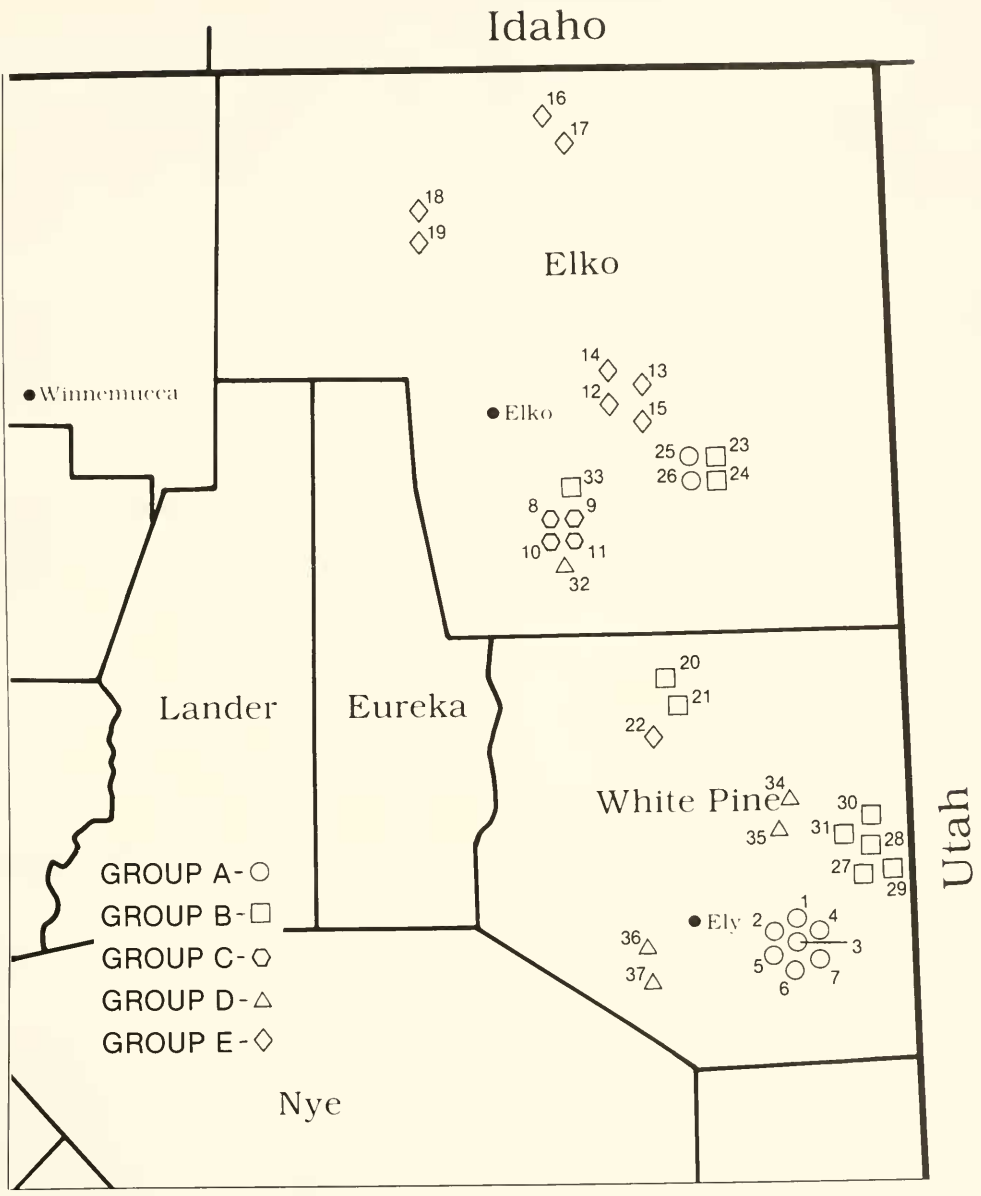

Fig. 1. Location of detailed study sites in Elko and White Pine counties of northeastern Nevada. The group designations indicate the location of the five TWINSPAN groupings.

ther elucidate the environmental factors associated with distribution of these stands of vegetation. Axis 1 (Figs. 2, 3) is significantly correlated with decreasing latitude. A north-south distribution of the stands goes from approximately 41 degrees to 39 degrees North latitude. This axis is also significantly correlated with a significant reduction in the number of species/stand from 22 to 18.

Axis 2 (Fig. 2) represents a gradient significantly correlated with increasing elevation, higher solar radiation intensities, and a somewhat reduced number of species. Elevation along the gradient increases from 2,600 to 2,800 m. The radiation index increases from 42 to 45 with a very slight but significant reduction in the number of species.

The distribution of the Axis 3 standard devi-

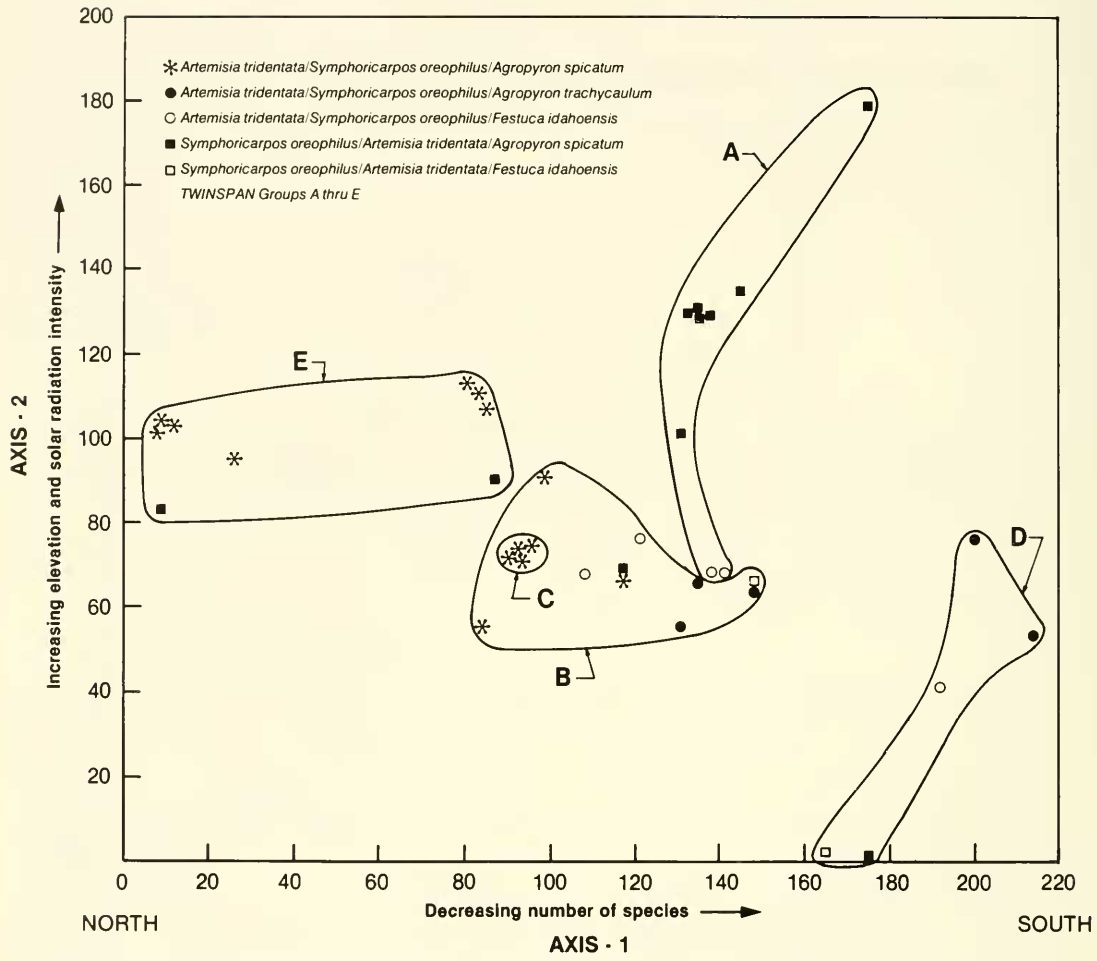

Fig. 2. DECORANA ordinations of Axis 1 and Axis 2 with separation of the five plant associations interpreted from the association table. Lines circle the TWINSPAN groups.

ations showed significant correlations with decreasing grass cover, shrub cover, and total vegetation cover along with an increase in the number of species per stand from 17.6 to 21.5. Grass cover decreased from 5.9 to 0.9%, shrub cover from 57.2 to 36.1%, and total vegetation cover from 65.7 to 37.6%.

Ordination of the 37 stands in this study showed significant relationships to environmental factors. The first axis (Axis 1) is related to latitude and species number in the stand and Axis 2 to elevation increases and the associated higher solar radiation intensities. Axis 3 is representative of a reduced level of shrub, grass, and total vegetation cover.

Further comparisons between the plant associations and the TWINSPAN groups show that the *Artemisia tridentata/Symphoricarpos oreophilus/Agropyron trichophorum* sites are found at southern locations within the study area and *Artemisia tridentata/Symphoricarpos oreophilus/Agropyron spicatum* stands are found further north. The other three plant associations are found at intermediate latitudes. Total vegetation cover was highest for *Artemisia tridentata/Symphoricarpos oreophilus/Festuca idahoensis* stands.

Soils

Soils associated with these mountain brush associations are primarily mollisols or alfisols, although two are inceptisols. Well over half have argillic horizons that are not restrictive to rooting. pH values are generally near neutral or slightly acidic. Epipedons are either ochric or mollic with a few more of the latter.

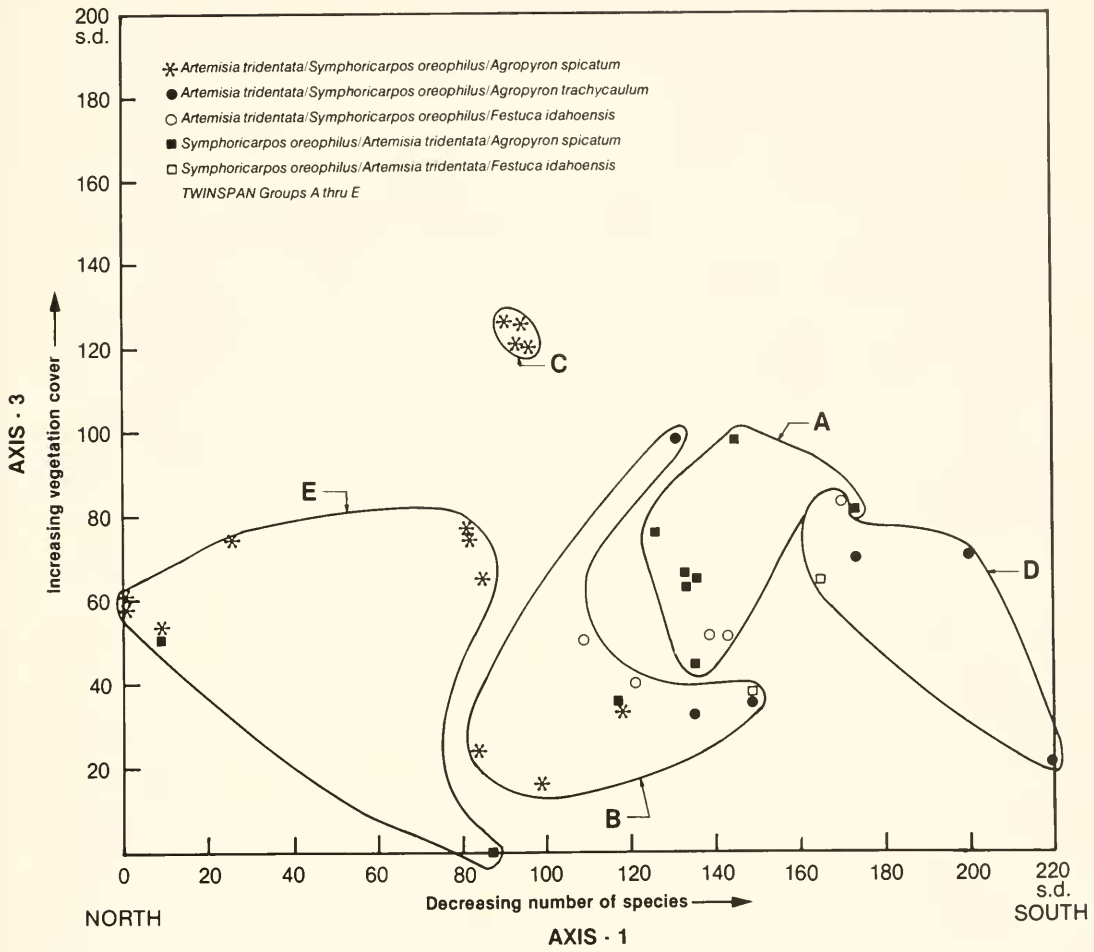

Fig. 3. DECORANA ordinations showing Axis 1 and Axis 3 with separation of the five plant associations interpreted from the association table. Lines circle the TWINSPAN groups.

The soil family textural classes are mostly fine-loamy, indicating good plant growth and rooting characteristics. Those soils that are clayey are also skeletal and indicate a good rooting medium (Table 7).

Soils supporting *Festuca idahoensis* have a deeper solum (A + B horizon) that averages 79 cm, while those soils supporting stands of either *Agropyron spicatum* or *Agropyron trachaycaulum* have a solum depth averaging only 68 cm. The *Festuca idahoensis* sites also have a higher litter cover, lower bare soil surface, and lower gravel and stone cover than do surface soils on the more xeric *Agropyron spicatum* and *Agropyron trachycaulum* associations. These soils are generally well drained, loamy, deep, sometimes rocky, and dark colored with many roots, no restrictive layers, and relatively high organic matter.

Discussion

Mountain brush rangeland associations dominated by either *Artemisia tridentata vaseyana* or *Symphoricarpos oreophilus* have not been studied extensively. The works of Blackburn et al. (1968a, b, c, 1971a) list only a few such associations. Most studies of the ecology of *A. tridentata* vegetation have generally ignored these low-acreage, high-producing plant associations.

Blackburn et al. (1969a) described an *Artemisia tridentata/Symphoricarpos vaccinoides* association in western Nevada with 30% cover of *A. tridentata* and only 3% cover for *S. vaccinoides*. Blackburn et al. (1968a,

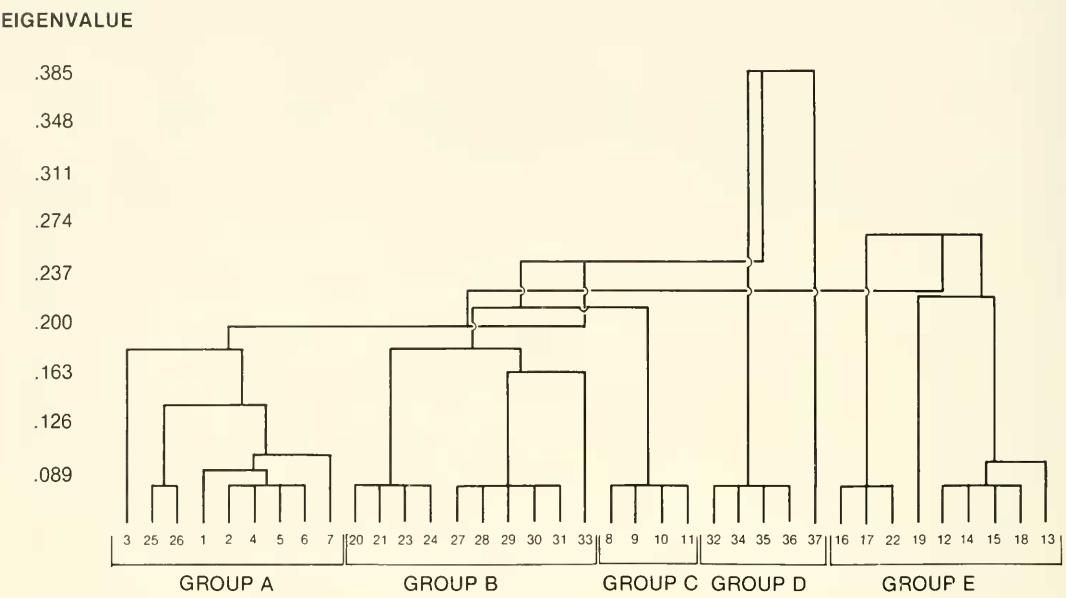

Fig. 4. TWINSPAN dendrology showing the separation of five groupings of the 37 study plots.

1971) described a low sagebrush association, *Artemisia longiloba/Poa sandbergii*, and an *Artemisia tridentata/Agropyron smithii/Poa nevadensis* association, both of which contain some *S. oreophilus*. Additionally, they described an *Artemisia tridentata/Symphoricarpos oreophilus/Agropyron spicatum* association with 16.3% cover for *Artemisia* and 15.6% cover for *Symphoricarpos*. The same association has 2.0% cover for *Agropyron spicatum* and 1.0% cover for *Festuca idahoensis*. Several low seral communities were described that have some *Symphoricarpos*. They were *Artemisia tridentata/Chrysothamnus viscidiflorus/Poa sandbergii/Wyethis mollis*, *Artemisia tridentata/Chrysothamnus viscidiflorus/Sitanion hystrix*, and *Artemisia tridentata/Poa sandbergii/Balsamorhiza sagittata*. Also they described an *Artemisia tridentata* (10.2% cover)/*Symphoricarpos oreophilus* (4.5%)/*Amelanchier pallida* (4.5%) association. Mooney (1985) recently described seven *Artemisia tridentata vaseyana* plant associations in the Great Basin. Many of these stands contain *Symphoricarpos oreophilus*.

Little biomass productivity data for these sites are available. However, their relatively greater number of species, deeper soils, and higher total ground cover lead to the conclusion that production is high for these communities relative to most other sagebrush-dominated plant associations. Both Daubenmire (1970) and Franklin and Dyrness (1969) described the *Festuca idahoensis/Symphoricarpos albus* habitat type. Daubenmire found that the total production of all vasculars was $30gm^{-2}$ while total grass production was $105m^{-2}$.

The groupings differentiated with the TWINSPAN dendrogram, apart from Groups A and C, do not show a strong relationship with the subjectively determined associations based on dominant species. Group A includes primarily *Symphoricarpos oreophilus/Artemisia tridentata/Agropyron spicatum* plant associations. Group C is made up of the *Artemisia tridentata/Symphoricarpos oreophilus/Agropyron spicatum* plant association. The other groupings all show greater variability. This suggests that objective classification approaches based on presence and absence of all species may give classifications that differ substantially from those based on the presence of designated dominant species which were done here in the association table analysis.

The *Artemisia-Symphoricarpos* associations may represent a moisture gradient as one goes from high *Artemisia* to low *Symphoricarpos* and the reverse. They do represent relatively low-acreage, high-producing sites within the *Artemisia* vegetation.

ACKNOWLEDGMENTS

The authors are indebted to Kenneth R. Riemer for assistance in gathering data; to Harry Summerfield and F. F. Peterson for assistance in classification of soils; to Hugh Mozingo for identification of certain taxa; and to Ed Kleiner, Stan Smith, and Robin Tausch for review of the manuscript.

LITERATURE CITED

BLACKBURN, W. H. 1967. Plant succession on selected habitat types in Nevada. Unpublished thesis, University of Nevada, Reno. 162 pp.

BLACKBURN, W. H., P. T. TUELLER, AND R. E. ECKERT, JR. 1968a. Vegetation and soils of the Crowley Creek Watershed. Univ. Nevada Expt. Sta. Bull. R-42. 60 pp.

_____. 1968b. Vegetation and soils of the Duckwater Watershed. Univ. Nevada Expt. Sta. Bull. R-40. 80 pp.

_____. 1968c. Vegetation and soils of the Mill Creek Watershed. Univ. Nevada Expt. Sta. Bull. R-43. 72 pp.

_____. 1969a. Vegetation and soils of the Churchill Canyon Watershed. Univ. Nevada Expt. Sta. Bull. R-45. 157 pp.

_____. 1969b. Vegetation and soils of the Pine and Mathew Canyon Watersheds. Univ. Nevada Expt. Sta. Bull. R-46. 111 pp.

_____. 1969c. Vegetation and soils of the Cow Creek Watershed. Univ. Nevada Expt. Sta. Bull. R-49. 80 pp.

_____. 1969d. Vegetation and soils of the Coils Creek Watershed. Univ. Nevada Expt. Sta. Bull. R-48. 81 pp.

_____. 1971. Vegetation and soils of the Rock Springs Watershed. Univ. Nevada Expt. Sta. Bull. R-83. 116 pp.

DAUBENMIRE, R. F. 1952. Forest vegetation of northern Idaho and adjacent Washington and its bearings on concepts of vegetation classification. Ecol. Monogr. 22: 301–330.

_____. 1970. Steppe vegetation of Washington. Washington Agric. Expt. Sta. Tech. Bull. 62. 131 pp.

FRANK, C., AND R. LEE. 1966. Potential solar beam irradiation on slopes. Tables for 30° to 50° latitude. U.S. Forest Service Research Paper RM-18. 116 pp.

HANSON, H. C., AND E. D. CHURCHILL. 1961. The plant community. Reinhold Publishing Corp., New York. 218 pp.

HILL, M. O. 1979. DECORANA, a FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Ecology and Systematics, Cornell University, Ithaca, New York.

HUNT, C. B. 1967. Physiography of the United States. W. H. Freeman and Co., San Francisco. 480 pp.

MCARTHUR, E. 1979. Sagebrush systematics and evaluation. Pages 14–22 *in* Proceedings Sagebrush Ecosystem Symposium, Utah, April 1978.

MOONEY, J. 1985. A preliminary classification of high-elevation sagebrush-grass vegetation in northern and central Nevada. Unpublished thesis, University of Nevada. 118 pp.

PASSEY, H. B., AND V. T. HUGIE. 1962. Sagebrush on relict ranges in the Snake River plains and northern Great Basin. J. Range Manage. 15: 273–278.

POULTON, C. E., AND E. W. TISDALE. 1961. A quantitative method for the description and classification of range vegetation. J. Range Manage. 14: 13–21.

WINWARD, A. H., AND E. W. TISDALE. 1969. A simplified chemical method for sagebrush identification. Forest, Wildlife, and Range Expt. Sta. Note No. 11, March 1969.

ZAMORA, B., AND P. T. TUELLER. 1973. *Artemisia arbuscula*, *A. longiloba*, and *A. nova* habitat types in northern Nevada. Great Basin Nat. 33(4): 253–264.